# RECORDING MEDIUM CONTAINING CONTENTS STREAM DATA RECORDED THEREON, RECORDING APPARATUS, AND REPRODUCING APPARATUS THEREOF



## BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to recording and reproducing content stream data, and more particularly, to a recording medium containing content stream data recorded thereon, a recording apparatus, and a reproducing apparatus thereof.

2. Description of the Related Art

Each of various contents, such as movies, music, etc, are generally referred to as a program.

FIG. 1 is the structure of the conventional program data.

Generally, content stream data forming a program is formed by one stream object (SOB). Referring to FIG. 1, an SOB is formed of a chain in which one or more stream object units (SOBU) are linked. An SOBU is a unit for recording and editing data, and a predetermined size of data. However, since the input and/or output speeds of data streams forming a program can change in recording and/or reproducing, the corresponding SOBU lengths on a time axis can be different from one another.

Meanwhile, an SOB contains one or more stream packs (S_PCK). That is, the SOB is formed by content stream data in which a plurality of stream packs stand in a row. Stream packs standing in a row are divided so that each divided unit has an identical predetermined size, and the resulting divided unit is a stream object unit (SOBU). Therefore, an SOBU can contain a plurality of stream packs, but it is possible that the start and end of the first or the last stream pack do not match the start or the end of the SOBU. That is, a stream pack can stretch over two SOBUs.

A stream pack is formed by a pack header and a stream packet. A stream packet contains one or more application packets (AP_PKT). The application packet (AP_PKT) is a piece of a bit stream which is input when a recording apparatus records data, or output when a reproducing apparatus reproduces data. Therefore, in front of an application packet a time stamp (ATS) is located. The ATS means reproducing time information of the application packet located at the back of the ATS.

Meanwhile, to arbitrarily access a program recorded as shown in FIG. 1, search information which is separately made is generally used. Search information can include information on the location of certain data in a program, program reproducing time information, and program recording time information. Search information can have various formats depending on application fields, however, to reduce the amount of information and enable quick search, a hierarchical structure is frequently used to indicate data in the program.

If search information forming a program is formed of three layers of a cell, an SOB, and SOBUs, the search information includes information on what a cell or cells correspond to a predetermined program, information on what an SOB or SOBUs correspond to a predetermined cell, and information on what an SOBU or SOBUs correspond to a predetermined SOB. Particularly, information on what an SOBU or SOBUs correspond to an SOB is referred to as a mapping list (MAPL).

A mapping list contains an incremental application packet arrival time (IAPAT), which indicates the duration of a corresponding SOBU. According to DVD-SR Draft 0.9, the arrival time of an application packet contained in the corresponding SOBU is needed for obtaining an IAPAT.

Meanwhile, according to DVD-SR Draft 0.9, the size of an application packet (AP_PKT_SZ) satisfies AP_PKT_SZ ≤ 2018*[SOBU_SZ] - 2. Here, SOBU_SZ denotes the size of an SOBU. This expression is made considering that at least 30 bytes are needed for a pack header and 2 bytes are needed for a header extension and a stuffing packet defined in a stream packet, assuming that one SOBU has a number of stream packs equal to the number of SOBU_SZs. That is, it is because the maximum area for application packets is the result obtained by subtracting 30 bytes from 2048 bytes for one SOBU and then again subtracting 2 bytes from the resulting 2018 bytes.

However, according to the above scope of the size of an application packet, a case where no ATS exist in one SOBU occurs.

FIG. 2 illustrates a case where an application time stamp (ATS) does not exist in a stream object unit (SOBU).

If the last stream pack contained in an SOB is located as shown in FIG. 2, the first byte forming an ATS is not included in SOBU #M-1, and since only a part of an

application packet formed in the last stream pack is located in SOBU #M, no included ATS exist.

As this, according to the size of an application packet defined in DVD-SR Draft 0.9, a case where a corresponding ATS does not exist, such as in SOBU #M-1 or SOBU #M, occurs. The IAPAT of an SOBU which has no corresponding ATS cannot be obtained, and therefore, a mapping list formed of the IAPAT as search information cannot be obtained. Accordingly, it is impossible to search a program.

Particularly, in DVD-SR Draft 0.9, it is prescribed that in a case where the last SOBU of an SOB does not have a corresponding ATS, the IAPAT be obtained using a copy of the ATS of the last application packet. However, according to the rule for obtaining an IAPAT, which is prescribed in DVD-SR Draft 0.9, both IAPAT(M-1), which is the IAPAT value of SOBU #M-1, and IAPAT(M), which is the IAPAT value of SOBU#M, are "0", and therefore, program search based on a mapping list formed of IAPAT cannot be carried out correctly. For, according to the prescription of DVD-SR Draft 0.9, IAPAT(i) should meet the following conditions:

1<=IAPAT(i) <212, i=1

1<=IAPAT(i) <212-1, 1<i<M

0<=IAPAT(i) <212-1, i=M

However, referring to FIG. 3, IAPAT(M-1) is "0" and does not satisfy the conditions.

## SUMMARY OF THE INVENTION

To solve the above problems, it is an object of the present invention to provide a recording medium containing content stream data recorded thereon, the content stream data having a data structure, in which a stream object unit (SOBU) included in a stream object (SOB) has a corresponding application time stamp (ATS) so that program search based on a mapping list can be correctly performed, a recording apparatus and a reproducing apparatus thereof.

To accomplish the above object of the present invention, there is provided a recording medium, on which an SOB containing at least one or more SOBUs, in which content stream data is recorded, and to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the

divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, is recorded, and the recording medium in which each of the SOBUs, excluding the SOBUs containing stuffing packets and the last SOBU, contains at least two entire ATSs.

It is preferable that the size of the application packet is small enough to include at least two entire ATSs and satisfies the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU. SOBU_SZ denotes the size of an SOBU.

The recording medium further includes a mapping list (MAPL) having an incremental application packet arrival time (IAPAT) indicating the duration of a corresponding SOBU, as search information for indicating what an SOBU or SOBUs are included in a certain SOB.

To accomplish the above object of the present invention, there is also provided a recording medium, on which an SOB containing at least one or more SOBUs, in which content stream data is recorded, and to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, is recorded, and the recording medium in which each of the SOBUs, excluding the SOBUs containing stuffing packets and the last SOBU, contains at least two entire ATSs, and the last SOBU contains a stuffing packet for correction, the stuffing packet which contains a predetermined ATS and is contiguously recorded to the stream pack.

It is preferable that the stuffing packet for correction is recorded in the last application packet, the ATS contained in the stuffing packet for correction further

contains a payload having the same value as the ATS contained in the last stream pack, the payload in which predetermined data is recorded, or not data is recorded, and "0" is recorded in the payload.

It is preferable that the size of the application packet is small enough to include at least two entire ATSs and satisfies the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

The recording medium further includes a mapping list (MAPL) having an incremental application packet arrival time (IAPAT) indicating the duration of a corresponding SOBU, as search information for indicating what an SOBU or SOBUs are included in a certain SOB.

To accomplish the above object of the present invention, there is also provided a recording apparatus for recording an SOB containing at least one or more SOBUs, to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, the recording apparatus having a control unit for generating a mapping list as search information; a clock generation unit for generating a clock value; a buffer unit for attaching the clock value provided from the clock generating unit to received content stream data, and outputting the content stream data at an appropriate speed by buffering the content stream data; a stream object unit (SOBU) generating unit for packing the content stream data output from the buffer unit and generating SOBUs so that each of the SOBUs, excluding the SOBUs containing stuffing packets and the last SOBU, contains at least two entire ATSs; and a recording unit for recording the SOBUs generated by the SOBU generating unit and the mapping list generated by the control unit.

It is preferable that the size of the application packet is small enough to include at least two entire ATSs and satisfies the following expression:

AP_PKT_SZ≤ SPayload_SZ*[SOBU_SZ/2] - [ ceil( (N_AHE+N_SByte)/2) + ATS_SZ]

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

The mapping list includes an incremental application packet arrival time (IAPAT) indicating the duration of a corresponding SOBU, as search information for indicating a corresponding SOBU of a corresponding SOB.

To accomplish the above object of the present invention, there is also provided a recording apparatus for recording an SOB containing at least one or more SOBUs, to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, the recording apparatus having a control unit for generating a mapping list as search information; a clock generation unit for generating a clock value; a buffer unit for attaching the clock value provided from the clock generating unit to received content stream data, and outputting the content stream data at an appropriate speed by buffering the content stream data; a stream object unit (SOBU) generating unit for including a stuffing packet for correction, which has an ATS having the same value as the last ATS among ATSs contained in the immediately preceding SOBU, into an SOBU, which has no corresponding ATS, in generating SOBUs; and a recording unit for recording the SOBUs generated by the SOBU generating unit and the mapping list generated by the control unit.

It is preferable that all SOBUs excluding the last SOBU contains at least two entire ATSs, the SOBU generating unit includes the stuffing packet for correction into the last SOBU, and the recording unit continuously records the stuffing packet after the last application packet contained in the SOB.

It is preferable that the ATS contained in the stuffing packet for correction has the same value as the ATS contained in the last stream pack, the stuffing packet for correction further contains a payload, in which predetermined data is recorded, or no data is recorded, and it is more preferable that the recording unit records "0" in the payload.

To accomplish the above object of the present invention, there is also provided a recording apparatus for recording an SOB containing at least one or more SOBUs, to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, the recording apparatus having a clock generation unit for generating a clock value; a buffer unit for attaching the clock value provided from the clock generating unit to received content stream data, and outputting the content stream data at an appropriate speed by buffering the content stream data; an SOBU generating unit for generating SOBUs by packing content stream data output from the buffer unit; a control unit for generating a mapping list as search information by regarding the last SOBU, which has no corresponding ATS, having a virtual ATS; and a recording unit for recording the SOBUs generated by the SOBU generating unit and the mapping list generated by the control unit.

It is preferable that the control unit generates a mapping list containing an IAPAT obtained by regarding the ATS of the last stream pack contained in the SOB as the virtual ATS.

It is preferable that the size of the application packet is small enough to include at least two entire ATSs and satisfies the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

To accomplish the above object of the present invention, there is also provided a reproducing apparatus for reproducing content stream data from a recording medium, on which an SOB containing at least one or more SOBUs, to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, is recorded, in which the size of application packet is small enough so that each of the SOBUs excluding the last SOBU has at least two entire ATSs, the reproducing apparatus having a reading unit for reading the mapping list and the SOBU as search information; a control unit for controlling the reading unit so as to read a corresponding SOBU, referring to the mapping list read by the reading unit; a clock generating unit for generating a clock value; an SOBU analyzing unit for extracting content stream data by analyzing the SOBU read from the reading unit by the control unit; and a buffer unit for outputting the content stream data provided from the SOBU analyzing unit, at an appropriate speed by buffering the content stream data based on a clock value provided by the clock generating unit.

It is preferable that the size of the application packet is small enough to include at least two entire ATSs and satisfies the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

The mapping list includes an incremental application packet arrival time (IAPAT) indicating the duration of a corresponding SOBU, as search information for indicating a corresponding SOBU of a corresponding SOB.

To accomplish the above object of the present invention, there is also provided a reproducing apparatus for reproducing content stream data from a recording medium, on which an SOB containing at least one or more SOBUs, to each

of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, is recorded, in which each of the SOBUs, excluding the last SOBU, contains at least two entire ATSs and the last SOBU contains a stuffing packet for correction, having a predetermined ATS, the reproducing apparatus having a reading unit for reading the mapping list and the SOBU as search information; a control unit for controlling the reading unit so as to read a corresponding SOBU, referring to the mapping list read by the reading unit; a clock generating unit for generating a clock value; an SOBU analyzing unit for extracting content stream data by analyzing the SOBU read from the reading unit by the control unit; and a buffer unit for outputting the content stream data provided from the SOBU analyzing unit, at an appropriate speed by buffering the content stream data based on a clock value provided by the clock generating unit.

It is preferable that the ATS contained in the stuffing packet for correction has the same value as the ATS contained in the last stream pack, and the stuffing packet for correction further contains a payload, in which predetermined data is recorded, or no data is recorded.

To accomplish the above object of the present invention, there is also provided a reproducing apparatus for reproducing content stream data from a recording medium, on which an SOB containing at least one or more SOBUs, to each of which one or more stream packs standing in a row are divided into units of a predetermined size and the divided units are sequentially assigned, in which each of the stream packs includes an application time stamp (ATS) and an application packet (A_PKT) into which content stream data is packed, is recorded, in which a mapping list, which is generated by regarding each of the SOBUs excluding the last SOBU containing at least two entire ATSs and the last SOBU having a virtual ATS, is recorded as search information, the reproducing apparatus having a reading unit for reading the mapping list and the SOBU as search information; a control unit for controlling the reading unit so as to read a corresponding SOBU, referring to the mapping list read by the reading unit; a clock generating unit for generating a clock value; an SOBU analyzing unit for extracting content stream data by analyzing the

SOBU read from the reading unit by the control unit; and a buffer unit for outputting the content stream data provided from the SOBU analyzing unit, at an appropriate speed by buffering the content stream data based on a clock value provided by the clock generating unit.

The mapping list contains an IAPAT generated by regarding a value, which is obtained by adding an integer to the ATS of the last stream pack contained in the SOB, as the predetermined ATS.

It is preferable that the size of the application packet is small enough for the SOBU to contain at least two entire ATSs and satisfies the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent by describing in detail a preferred embodiment thereof with reference to the attached drawings in which:

FIG. 1 is the structure of the conventional program data;

FIG. 2 illustrates a case where an application time stamp (ATS) does not exist in a stream object unit (SOBU);

FIG. 3 illustrates the conventional method to cope with a case where an ATS does exist in the last SOBU;

FIG. 4 is the data structure according to a first embodiment of the present invention;

FIG. 5 is the data structure according to a second embodiment of the present invention;

FIG. 6 is a block diagram of a recording apparatus according a preferable embodiment of the present invention;

FIG. 7 is a block diagram of a reproducing apparatus according a preferable embodiment of the present invention; and

FIG. 8 is a block diagram of a recording and reproducing apparatus according a preferable embodiment of the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, embodiments of the present invention will be described in detail with reference to the attached drawings. The present invention is not restricted to the following embodiments, and many variations are possible within the spirit and scope of the present invention. The embodiments of the present invention are provided in order to more completely explain the present invention to anyone skilled in the art.

A recording medium according to the present invention is a re-writable recording medium, and a user can directly record and edit a program formed of content stream data. Recording content stream data means to record input content stream data as it is without encoding. That is, audio or video stream data such as music or movies is received, buffered, packed in predetermined recording units, and recorded in the recording medium.

Digital Versatile Disc-Stream Recording (DVD-SR), which is a recording medium according to the present embodiment, includes a program recorded in a stream object (SOB), and search information for program navigation.

Here, as in the prior art, the SOB means a program, such as music or a movie, which is recorded in the form of content stream data, and includes one or more stream packs (S_PCK). Stream packs standing in a row are divided so that each divided unit has an identical predetermined size, and the resulting divided unit is a stream object unit (SOBU). Therefore, an SOBU can contain a plurality of stream packs, but it is possible that the start or end of the first or the last stream pack do not match the start or end of the SOBU.. That is, a stream pack can stretch over two SOBUs.

A stream pack is formed by a pack header and a stream packet. A stream packet contains one or more application packets (AP_PKT). The application packet (AP_PKT) is a piece of a bit stream which is input when a recording apparatus

records data, or output when a reproducing apparatus reproduces data. In front of an application packet a time stamp (ATS) is located. The ATS means reproducing time information of the application packet located at the back of the very ATS.

Meanwhile, search information has a hierarchical structure containing information on what cells are corresponding to a predetermined program, what is an SOB corresponding to a predetermined cell, and what SOBUs are corresponding to a predetermined SOB. Particularly, information on what SOBUs are corresponding to an SOB is referred to as a mapping list (MAPL). A mapping list contains an incremental application packet arrival time (IAPAT) indicating the duration of a corresponding SOBU. A rule for obtaining an IAPAT will be explained later.

Meanwhile, each of the SOBUs, excluding the last SOBU, contained in a predetermined SOB according to the present invention has at least two entire ATSs. That is, the first byte of each of at least two ATSs is contained in a corresponding SOBU. Because the size of an application packet according to the present invention satisfies the following expression. However, an exception to this is an SOBU containing a stuffing packet. Here, the stuffing packet is packet data which is compulsorily inserted to prevent an overflow of an IAPAT when an SOBU cannot be filled with application packets even in a maximum duration that can be expressed by an IAPAT at a low bit rate. The stuffing packet has no relation with the content, and is used for timing regeneration needed in reproducing.

The size of an application packet is limited to the scope expressed by the following expression:

$$AP\_PKT\_SZ \leq SPayload\_SZ*[SOBU\_SZ/2] - [\ ceil(\ (N\_AHE+N\_SByte)/2) + ATS\_SZ]$$

Here, AP_PKT_SZ denotes the size of an application packet, ATS_SZ denotes the byte size of an ATS, SPayload_SZ denotes the size of data space for containing information, excluding a fixed header area of a stream pack, N_AHE denotes the number of application header extensions of a corresponding SOBU, and N_SByte denotes the number of stuffing bytes of a corresponding SOBU.

The expression can be simplified when it is applied to a special case as follows.

That is, as described in the explanation of the prior art, considering that at least 30 bytes are needed for a pack header and 2 bytes are needed for a header extension and a stuffing packet defined in a stream packet, assuming that one SOBU has a number of stream packs equal to the number of SOBU_SZs, 2018*[SOBU_SZ]-2 is the remaining area. Here, 2018 represents the size of data space (SPayload_SZ) for containing information, excluding the size of fixed header area, in a stream pack of 2048 bytes. However, if considering the size of an ATS is 4 bytes, the size of an application packet is made to be less than or equal to 2018*[SOBU_SZ/2]-6, each of the SOBUs, excluding the SOBUs containing stuffing packets and the last SOBU, contains the first byte of each of at least two ATSs. Therefore, the above expression is simplified as the following expressions:

$$(AP\_PKT\_SZ+4) * 2 \leq 2018 * [SOBU\_SZ] - 2 * 2$$

$$AP\_PKT\_SZ \leq 2018 * [SOBU\_SZ/2] - 6$$

Meanwhile, a data structure for making the last SOBU have an IAPAT according to the present invention can be implemented in the two embodiments which will now be explained.

First, the first embodiment of a data structure for making the last SOBU have an IAPAT will now be explained.

FIG. 4 is the data structure according to the first embodiment of the present invention.

Referring to FIG. 4, an SOB is formed of an SOBU chain, in which M SOBUs are connected. Since the size of an application packet is as described above according to the present invention, each of SOBUs excluding the last SOBU contains the first byte of each of at least two ATS. That is, SOBU #M-1 contains the first bytes of ATS #N-1 and ATS #N.

Meanwhile, SOBU #M does not contains ATS, but contains all or part of application packet AP_PKT #N. That is, when an ATS contained in the last SOBU, SOBU #M, does not exist, a stuffing packet for correction 100 is recorded after the last application packet AP_PKT #N, according to the present embodiment. The stuffing packet for correction 100 is formed of ATS #N 101 and a payload 102. That is, the ATS contained in the stuffing packet for correction has a value obtained by copying ATS #N attached to AP_PKT #N. In the payload 102, "0" is recorded

according to the present embodiment. Meanwhile, since the SOB ends with the substantially last application packet AP_PKT #N, and data recorded after the last application packet AP_PKT #N is not read in reproducing the SOB, data format and content recorded in the payload 102 can change in various ways when necessary. As the case may be, no data is recorded in the payload 102.

Next, the data structure for making the last SOBU have an IAPAT according to the second embodiment will now be explained.

FIG. 5 is the data structure according to the second embodiment of the present invention.

Referring to FIG. 5, an SOB is formed of an SOBU chain, in which M SOBUs are connected. Since the size of an application packet is as described above according to the present invention, each of SOBUs excluding the last SOBU contains the first byte of each of at least two ATSs. That is, SOBU #M-1 contains the first bytes of ATS #N-1 and ATS #N.

At this time, as described above referring to FIG. 4, the ATS contained in SOBU #M has the same value as the ATS #N attached to AP_PKT #N, but is not actually recorded. That is, in calculating an IAPAT value required for recording a mapping list as search information, ATS #N is read and then this value is regarded as the ATS contained in SOBU #M. However, the IAPAT obtained by regarding the ATS #N as the ATS of SOBU #M is recorded in the mapping list as search information.

According to the first embodiment and the second embodiment described above referring to FIGS. 4 and 5, the first ATS of SOBU #M-1 is ATS #N-1 and the first ATS of SOBU #M is ATS #N. Since the first ATSs are different to each other, the IAPAT of SOBU #M-1 is not "0". That is, according to the rules defined in DVD-SR Draft 0.9, the IAPAT values of all SOBUs can be correctly obtained. Therefore, since each SOBU has an IAPAT value which can be distinguished from other IAPAT, program search referring to a mapping list can be performed smoothly without an error.

Meanwhile, according to DVD-SR Draft 0.9, the rule for obtaining an IAPAT is as follows.

For i-th SOBU, SOBU(i), excluding SOBU #M, when an SOB contains M SOBUs, a value obtained by accumulating IAPATs from the first IAPAT, IAPAT(1) to the i-th IAPAT, IAPAT(i), should be greater than or equal to the arrival time of the first application packet of SOBU(i+1), and less than a value obtained by adding "1" to the arrival time of the first application packet of SOBU(i+1). At this time, an IAPAT has an integer value and the initial value of an IAPAT is "0". This can be expressed by the following expression:

SOBU_S_APAT(i+1) <= SUM_IAPAT(i) < SOBU_S_APAT(i+1) + 1

Here, SOBU_S_APAT(i+1) denotes the arrival time of the first application packet contained in SOBU #i+1, and SUM_IAPAT(i) denotes a value obtained by accumulating the IAPATs of SOBU#i and all preceding SOBUs.

Also, as for SOBU #M, a value obtained by accumulating all IAPATs is greater than the arrival time of the last application packet contained in the SOBU #M, and less than or equal to a value obtained by adding "1" to the arrival time of the last packet contained in the SOBU #M. This can be expressed by the following expression:

SOBU_E_APAT(M) < SUM_IAPAT(M) <= SOBU_E_APAT(M) +1

Here, SOBU_E_APAT(M) denotes the arrival time of the last application packet contained in SOBU #M.

FIG. 6 is a block diagram of a recording apparatus according a preferable embodiment of the present invention.

Referring to FIG. 6, the recording apparatus 5 records contents such as music or movies in one SOB having the data structure described above, and has a buffer unit 51, a clock generating unit 52, an SOBU generating unit 53, a recording unit 55, and a control unit 56. The buffer unit 51 receives content streams from the outside and output the content streams at an appropriate speed by buffering the content streams based on the clock values provided from the clock generating unit 52. The SOBU generating unit generates SOBUs by packing content streams. The recording unit 55 records SOBUs and search information such as a mapping list in an optical disc 500 based on controls from the control unit 56. The control unit 56 generates a mapping list and provides the mapping list to the recording unit 55, while controls the

entire recording apparatus 5 so that content streams are recorded in the optical recording medium 500.

Based on the structure described above, first, the recording method according to a first embodiment of the present invention will now be explained.

When content streams are input to the buffer unit 51 from such an application apparatus as a set-top-box, and a user pushes a recording button (not shown) of the recording apparatus, the control unit 56 resets the clock generating unit 52. Then, the clock generating unit 52 generates clock values from "0" and provides the clock values to the buffer unit 51.

The buffer unit 51 attaches the clock values received from the clock generating unit 52 to the received content streams, and outputs the received content streams at an appropriate speed by buffering the content streams. The SOBU generating unit 53 packs the content streams received from the buffer unit 51, and generates SOBUs. The generated SOBUs are transmitted to the recording unit 55, and the recording unit 55 records the received SOBUs in the optical disc 500 based on the controls from the control unit 56.

At this time, as shown in FIG. 4, if each of the SOBUs contained in the SOB, excluding the last SOBU, contains at least two ATSs and the last SOBU has not ATS, a stuffing packet for correction 100 is recorded contiguously after the last application packet AP_PKT #N. As the ATS contained in the stuffing packet for correction 100 in the present embodiment, the preceding ATS #N 101 is copied and then recorded. "0" is recorded in the payload according to the present embodiment.

Also, the recording unit 55 records the mapping list, provided form the control unit 56, as navigation data for search recording area of the optical disc 500.

The recording method according to a second embodiment of the present invention will now be explained.

When content streams are input to the buffer unit 51 from such an application apparatus as a set-top-box, and a user pushes a recording button (not shown) of the recording apparatus, the control unit 56 resets the clock generating unit 52. Then, the clock generating unit 52 generates clock values from "0" and provides the clock values to the buffer unit 51.

The buffer unit 51 attaches the clock values received from the clock generating unit 52 to the received content streams, and outputs the received content streams at an appropriate speed by buffering the content streams. The SOBU generating unit 53 packs the content streams received from the buffer unit 51, and generates SOBUs. The generated SOBUs are transmitted to the recording unit 55, and the recording unit 55 records the received SOBUs in the optical disc 500 based on the controls from the control unit 56.

Also, the recording unit 55 records the mapping list, provided form the control unit 56, as navigation data for search information recording area of the optical disc 500. Here, the mapping list is generated by the control unit 56 and provided to the recording unit 55. More specifically, as shown in FIG. 5, the control unit 56 reads ATS #N, regards this value as the ATS of SOBU #M, and records an IAPAT value, which is obtained by the rule described above, based on ATS #N, in the mapping list. That is, the ATS of SOBU #M has the same value as ATS #N, but the value is not a value actually recorded as data, but a virtual value used by the control unit 56 in calculating an IAPAT value forming the mapping list.

FIG. 7 is a block diagram of a reproducing apparatus according a preferable embodiment of the present invention.

Referring to FIG. 7, the reproducing apparatus reproduces contents from an optical disc 600 on which data having the data structure described referring to FIGS. 4 through 6 is recorded, and has a control unit 66, a reading unit 65, an SOBU analyzing unit 64, a clock generating unit 62, and a buffer unit 61.

The control unit decodes various control information including a mapping list and controls the entire reproducing apparatus so that contents recorded on the optical recording medium 600 can be reproduced based on user's requirements. The reading unit 65 reads data from the optical recording medium 600. The SOBU analyzing unit 64 extracts content stream data forming contents by analyzing read SOBUs, and outputs content stream data at an appropriate speed by buffering content stream data based on the clock values provided from the clock generating unit 62.

Based on the structure described above, first, the reproducing method according to a first embodiment of the present invention will now be explained.

If a user requests to reproduce predetermined contents by pushing a reproducing button (not shown) of the reproducing apparatus, the control unit 66 commands the reading unit 65 to read search information, including a mapping list, recorded in the optical recording medium 600, receives search information, including the mapping list, provided from the reading unit 65, and finds out the corresponding SOB or the corresponding SOBU. At this time, as shown in FIG. 4, even if each of SOBUs contained in the SOB, excluding the last SOBU, has at least two ATSs and the last SOBU has not ATS, a stuffing packet for correction 100, which contains ATS #N, is recorded in the optical recording medium 600, following the last application packet AP_PKT #N, and a mapping list having an IAPAT obtained based on the stuffing packet for correction 300 is recorded as search information. Therefore, searching for contents and reproducing contents in a desired location can be smoothly performed.

Meanwhile, the control unit 66 resets the clock generating unit 62. Then, the clock generating unit 62 generates clock values from "0" and provides the clock values to the buffer unit 61.

The reading unit 65 reads recorded contents and provides the contents to the SOBU analyzing unit 64. The SOBU analyzing unit 64 extracts content stream data from the provided SOBU. The buffer unit 61 outputs the corresponding content stream data at a time when the clock value provided from the clock generating unit 62 becomes the same as the clock value attaches to the received content stream data.

Next, the reproducing method according to a second embodiment of the present invention will now be explained.

If a user requests to reproduce predetermined contents by pushing a reproducing button (not shown) of the reproducing apparatus, the control unit 66 commands the reading unit 65 to read search information, including a mapping list, recorded in the optical recording medium 600, receives search information, including the mapping list, provided from the reading unit 65, and finds out the corresponding SOB or the corresponding SOBU. At this time, as shown in FIG. 5, even if each of SOBUs contained in the SOB, excluding the last SOBU, has at least one entire ATS and ATS contained in the last SOBU does not exist, a mapping list, which contains

an IAPAT obtained by regarding SOB #M having ATS #N, is recorded as search information, and therefore searching for contents and reproducing contents at a desired location can be performed.

Meanwhile, the control unit 66 resets the clock generating unit 62. Then, the clock generating unit 62 generates clock values from "0" and provides clock values to the buffer unit 61.

The reading unit 65 reads recorded contents and provides the contents to the SOBU analyzing unit 64. The SOBU analyzing unit 64 extracts content stream from the provided SOBU. The buffer unit 61 outputs the corresponding content stream at a time when the clock value provided from the clock generating unit 62 becomes the same as the clock value attached to the received content stream data.

FIG. 8 is a block diagram of a recording and reproducing apparatus according a preferable embodiment of the present invention.

Referring to FIG. 8, the recording and reproducing apparatus 7 is implemented by combining the recording apparatus 5 of FIG. 6 and the reproducing apparatus 6 of FIG. 7 in one unit, and has a recording/reading unit 75, an SOBU generating unit 73, an SOBU analyzing unit 74, a buffer unit 71, a clock generating unit 72, and a control unit 76, so that in recording, each of content such as music and a movie is recorded as one SOB having the data structure described above, and in reproducing, contents are reproduced from an optical disc 700 on which data having the structure explained referring to FIGS. 4 through 6, are recorded.

The buffer unit 71, in recording, receives content stream data from the outside, and outputs the content stream data at an appropriate speed by buffering the content stream data based on clock values provided from the clock generating unit 72, and in reproducing, outputs content stream data at an appropriate speed by buffering the content stream data based on clock values provided from the clock generating unit 72.

The SOBU generating unit 73 generates SOBUs by packing content stream data. The SOBU analyzing unit 74 extracts content stream data forming contents by analyzing SOBUs.

The recording/reading unit 75, in recording, records SOBUs and search information such as a mapping list on the optical disc 700 based on the control of the

control unit and content stream data packed in SOBUs, and in reproducing, reads search information, including a mapping list, or SOBUs recorded in the optical disc 700 at the request of the control unit 76.

The control unit 76, in recording, generates a mapping list and provides the mapping list to the recording/reading unit 75 and controls the entire recording and reproducing apparatus 7 so that content stream data is recorded on the optical disc 700, and in reproducing, decodes various control information, including the mapping list, and controls the entire recording and reproducing apparatus so that contents recorded on the optical disc 700 can be reproduced.

The recording method and reproducing method of the recording and reproducing apparatus having the structure described above are the same as those of the above-described recording apparatus and reproducing apparatus, respectively, and the explanation will be omitted.

According to the methods and apparatuses above described, the IAPAT values of all SOBUs can be correctly obtained, and therefore, program search referring to a mapping list can be smoothly performed without an error.